The experience of the word, when the meaning has dropped away, is generally reported as like that of a nonsense-syllable,—a combination of sounds, neither familiar nor unfamiliar, which has no meaning other than that of mere verbal sound. Occasionally also a 'feeling of blankness' is reported. In some instances, as a result of elision of the accentuation of a vowel or consonant in rapid pronunciation, words become strange, as if they had never before been experienced.[3] There is apparently no shift from a common-sense to a psychological attitude; the sound merely loses its individual, particular, familiar meaning and becomes either a bare word among words or something strange and unknown.

The course of the experience, according to the reports, is of two kinds. The meaning may seem to die out gradually, or it may lapse suddenly after a certain number of repetitions. What exactly happens in the former case, neither *O* was able to say. The effect is probably due to the progressive insistence of the sheer sound of the word; the meaning is thus forced, as it were, into the background, and its loss in distinctness is taken to be a loss in meaning itself. On this point, however, further observations are needed.

*Conclusions.* (1) Given a stably passive attitude on the part of the observer, the meaning of a familiar monosyllabic noun repeated aloud three times per sec. drops away in about 3 to 3.5 sec. (2) There is a tendency, as practice advances, for varieties and fluctuations of meaning to give place to an habitual meaning characterized by our observers as a 'familiar feel.' (3) Meaning may lapse suddenly or die out gradually: the course of experience in the latter case is obscure.

## XLV. The Adjustment of the Hering Color-Blindness Apparatus

By M. Cowdrick and M. Winfield

Some years ago the senior editor of these studies published a note of inquiry[1] concerning an *Anweisung* or set of directions for the adjustment of the Hering Color-Blindness Apparatus, whch had been mentioned by Hering in his description of the apparatus[2] but which had never been obtained by the Cornell Laboratory. Efforts to procure it from Hering himself, from Rothe and from Spindler and Hoyer, the earlier and later manufacturers of the instrument, and from other promising sources had failed; and a request was made for the loan of it, if it were possessed by any reader of the *Journal.* Thus far no reply to the request has been received; and we have therefore undertaken to determine for ourselves what adjustments of the apparatus facilitate the performance of a test for color-blindness,

[3] For other instances of the meaning of strangeness, see Messer, *loc. cit.*

[1] E. B. Titchener, Laboratory Notes, this *Journal,* xxv, 1914, 298.

[2] E. Hering, Zur Diagnostik der Farbenblindheit, *Arch. f. Ophthalm.,* xxxvi, 1, 1890, 217.

and also to obtain norms which may serve as guide to the ready diagnosis of type. We publish an account of our experiments in the hope that it may be useful to other laboratories which possess the apparatus.

We begin with a brief description of the instrument.[3] At the bottom of a short vertical tube is a circular field which, in the test for color-blindness, consists of two semi-circular fields, due the one to a red, the other to a green stimulus. The former is furnished by a window filled with a red glass set in the floor of a light-chamber and illuminated by white light from the surface of a reflector. The reflector moves on a horizontal axis through 120°, and its position (and therefore the amount of reflected light) is marked by a pointer which travels over a graduated arc. When the pointer is at 0° the red is at zero, when it is at 120° the red is at maximal intensity. The hue of the red, which is slightly orange, may be changed by the admixture of blue. This blue light comes from another window filled with blue glass set in the left side of the light chamber and illuminated by a reflector which moves on a vertical axis through 120°. The light, after passing through the blue window, is reflected into the eye of the observer from a surface of clear glass set at an angle of 45°. Since the red rays pass through the same clear glass, they may be mixed with the blue in variable amounts, so that it is possible to obtain all hues from yellowish red to violet. The green stimulus comes from a window of green glass set in the right of the light chamber and illuminated by a reflector in every way similar to that of the blue; its light is reflected into the eye from a total-reflecting mirror set at an angle of 45°. The task of the observer who is to be tested for color-blindness is to match the two semicircular fields in tint and in hue. The match for tint is made by changing the intensity of the green, and that for hue by changing the intensity of the blue stimulus. The intensity of the red stimulus is fixed by the experimenter at the beginning of the test, and is not altered throughout its course. The nature of the stimuli presented to the observer thus depends upon the initial setting of the three reflectors; and that of the red is particularly important. And this was precisely the information which Hering was supposed to furnish in the *Anweisung,* and which we undertook in the first instance to determine.

We began by working in daylight with the instrument facing a well-lighted window. We set all three reflectors at 60° of arc; for we argued that, since all three were graduated to 120°, and since we should be able to obtain more or less as might be necessary of the green and blue components, that was the logical starting point. Under these conditions we found no difficulty in making diagnostic tests; but we found also, as Hayes had already discovered,[4] that the scale-readings were of no value for comparative purposes because they were conditioned upon the intensity of the general illumination. Matches made on a cloudy varied so much from those made on a cloudless day that the scale-readings were in no way comparable.

We decided, therefore, to move the apparatus to the dark room, and to employ artificial illumination. For this purpose we placed directly in front of the instrument an artificial daylight lamp consisting of a

[3] The apparatus is figured by E. B. Titchener, *Experimental Psychology* I., ii., 1901, 7; Text-Book of Psychology, 1910, 84.

[4] S. P. Hayes, Color Sensations of the Partially Color-Blind, *Amer. Jour. Psychol.,* xxii, 1911, 395.

100-watt nitrogen-filled Mazda lamp whose light was filtered through an 8-3/8 in. roundel of Gage's glass.[5] The lamp was so placed that the center of the roundel was approximately opposed to the center of the light-chamber at a distance of about 30 cm. All lateral light was enclosed by the conical reflector to which the roundel is attached. The electric current was taken from the 110-volt A. C. of the university lighting system. In this way the interior of the apparatus was flooded with diffused light; no direct rays impinged upon any one of the windows; and no shadows fell upon the reflectors. We found this arrangement adequate to our purpose.

*Procedure of the Test.* In making a test for partial color-blindness, we place a green glass in the right (to one facing the open side of the apparatus), a red glass in the floor, and a blue glass in the left aperture of the light-chamber. All reflectors are set at 60° of arc, and the iris diaphragm is opened to give a maximal field. *O* is then instructed to look into the tube with his right eye, and to say whether the nearer (green) half is lighter or darker than the farther (red) half of the circular field. If he says 'lighter,' he is instructed to turn the knob on his left hand slowly to the right,[6] if 'darker' to the left, until the two halves of the field appear equal in tint or brightness. When *O* has done his best,[7] he is told to rest his eye for some minutes. Then he is asked to look again, with the same eye, and to say whether the nearer (green) field is *yellower* or *bluer* than the farther (red) field.[8] If he says 'yellower' he is told to turn the knob on his right hand slowly to the left, if 'bluer' to the right, until the two halves are alike in hue. Since this determination has probably altered the brightness-relation of the two fields, the match for tint must again be made as in the first instance; and when this is done, slight corrections for hue may once more be necessary. The two procedures are thus alternated, until the semicircular fields are identical in tint and in hue. When the final match is made, we have found it advisable to have *O* verify it after some minutes of rest. Then the scale-readings are recorded; the reflectors are set back to their original positions, and the test is made for the left eye.

*Results.* We give the scale-readings in degrees of arc for three *O*'s who, as tested by the Nagel Cards, are 'green-blind' (deuteranopes), and for one *O* who by the same test is a 'red-blind' (protanope). Since in all cases the reflector for 'red' remained fixed at 60° of arc, we do not repeat this value in the table.

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[5] For further description of this lamp, see A. J. Brown, Some Uses of Artificial Daylight in the Psychological Laboratory, this *Journal,* xxvii, 1916, 427.

[6] Note that the knob on *O*'s left controls the reflector on *E*'s right.

[7] *E* need not insist on the accuracy of *O*'s match at this stage; the aim is to bring the two fields approximately together in tint, so that the match for hue (which is the next stage) may be facilitated.

[8] Color-blind *O*'s sometimes insist that the two fields are green and red, in which case they must be told emphatically that the instruction was not concerned with green and red, but only with yellow and blue. The cues to their meanings of red and green disappear when the final match is made.

| Obs. | Stimuli | Right eye | | Left eye | |
|---|---|---|---|---|---|
| | | 1st Trial | 2nd Trial | 1st Trial | 2nd Trial |
| *L. C.* | G | 47 | 42 | 46 | 46 |
| | B | 56 | 56 | 60 | 57 |
| *B.* | G | 44 | 43 | 46 | .. |
| | B | 61 | 63 | 61 | .. |
| *O. C.* | G | 45 | .. | 46 | .. |
| | B | 55 | .. | 55 | .. |
| *L.* | G | 37 | 32 | 35 | 32 |
| | B | 42 | 47 | 42 | 41 |

If it is recalled that all reflectors were set originally at 60° of arc, and that a setting at 0° means zero intensity, it will be seen that for all *O*'s the green half of the field was lighter than the red, but that the difference for *L* was much greater than for the other *O*'s. *L* is, however, a protanope; R appears much darker to him than to the deuteranopes; and G must therefore be reduced by a greater amount. It will be seen also that for all *O*'s except *B* the green stimulus is yellower than the red; *B* adds 1 to 3 degrees of blue to the red in making his match, whereas the other observers either subtract blue or make no change. We believe, however, that this result is not significant. All three deuteranopes reported the two fields as fairly well matched in hue before any change was made; and, moreover, *B* was in doubt whether the hue of his final match was yellow or blue. The other observers reported it as slightly yellowish. On the other hand, the fact that *L* requires much less blue than the other observers brings his case into agreement with the results of previous experimenters, who have found that protanopes demand less blue in a mixture of spectral red and blue to match an intermediate color in the yellow region than do deuteranopes.[9]

Our results appear, therefore, to be diagnostic. No doubt, further tests may show greater variation among observers than we have as yet found. But the close agreement of the three deuteranopes whom we have tested, together with the quantitative results which show difference in type, bespeak the usefulness of the Hering apparatus when the illumination is brought under control. Many other combinations of colors than those we have used may be employed; and the apparatus lends itself to attack upon other problems beside those of partial color-blindness. We are, for example, at present applying it to a study of the 'normal Rayleigh equation,' the matching of spectral red and green to yellow; we hope to publish results in the near future.

*Summary.* We have no evidence that the *Anweisung* to the use of the Hering Color-Blindness Apparatus was ever distributed. If it was not, the reason may lie in the fact that the instrument is valueless for comparative purposes if set up in diffuse daylight, and that Hering was reluctant to commit himself to any specific source of artificial illumination available at the time when the apparatus was constructed.

[9] See J. H. Parsons, *Colour Vision*, 1915, 163 f., and the references there cited.

Under our conditions of observation, red-green-blind persons of the ordinary type (deuteranopes or 'green-blinds') find an equation 60° R + 60° B = 60° G fairly satisfactory in hue. A better testing equation, for hue and tint together, is 60° R + 58° B = 45° G.

Red-green-blind persons of the less common type (protanopes or 'red-blinds') may be tested by the equation 60° R + 43° B = 34° G.

These figures are given with the reserve made necessary by the fewness of our observers. Color-blind subjects must be waited for, and their time is not always at the psychologist's disposal. We hope to repeat the observations in further instances.

## XLVI. Adaptation of Superficial Pain

By H. H. Straus and R. F. Uhlmann

As a rule, the authors who discuss pain say nothing about adaptation. Their silence probably means that, under ordinary circumstances of stimulation, adaptation is not observed: perhaps because the phenomenon is not insistent enough to force itself generally upon attention, perhaps because the facts themselves point to continuity of pain with continued stimulation. Continuity is, indeed, suggested by the result of continuous intensive stimulation and by instances of pathological pain, as of course also by the effect of intermittent stimulation even if weak; but adaptation may very well occur with weak continuous stimulation. Cases of the disappearance of pain so aroused have, in fact, been reported. Murray "makes the accidental discovery that superficial pain adapts out almost as readily as superficial contact." She remarks further that "mapping of the same area for pain [as had previously been mapped by a needle-stimulus] with an overheated brass rod, lightly applied, gave practically identical results as regards the position of the points and the occurrence of fatigue."[1] There are also passages in von Frey's writings which indicate a like observation. "Der Cornea (und Conjunctiva) eigenthümlich ist ferner die Erscheinung, dass ein nicht weit über der Schwelle liegender Reiz (1 — 5 gr/mm² für die Cornea) an vielen Puncten im ersten Moment der Berührung nicht gefühlt wird, dass aber bei andauernder Berührung Schmerzempfindung auftritt, *die entweder nach einigen Secunden wieder verschwindet,* oder was häufiger der Fall, soweit anschwillt, dass die Reizung unterbrochen werden muss."[2] Again, in speaking of the conditions of pain in general, von Frey remarks: "Bei andauernder Deformation ist die Schmerzempfindung, *schwächste Reize ausgenommen,* andauernd."[3] It seems, therefore, that under

[1] E. Murray, A Qualitative Analysis of Tickling, *Amer. Jour. Psychol.,* 1908, xix, 304; 305.

[2] M. v. Frey, Beiträge z. Physiol. des Schmerzsinns, *Ber. ü. d. Verhandl. d. Königl. Sächs. Ges d. Wiss z. Leipzig,* 1894, xlvi, 1, 193 (italics ours).

[3] *Untersuch ü. d. Sinnesfunctionen der menschlichen Haut,* 1896, 261 (italics ours).